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EFFECTS OF INGREDIENT RATIO AND PACKAGING ON THE QUALITY OF TOFU ENRICHED WITH WOOD EAR MUSHROOM (*Auricularia auricula-judae*)

Doan Phuong Linh[*], Nguyen Thi Hong Xuyen, Nguyen Xuan Hong, and Bui Thi Ngoc Thao

Faculty of Biological, Chemical and Food Technology, Can Tho University of Technology, Vietnam

**Corresponding author, Email: dplinh@ctuet.edu.vn*

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Abstract

*This study evaluates the effects of soybean-to-water ratio during grinding, supplementation level of wood ear mushroom (*Auricularia auricula-judae*), and packaging type on the sensory quality, texture, and storage stability of tofu. In the first experiment, tofu samples were prepared using three soybean-to-water ratios (1:7, 1:8, and 1:9) combined with three levels of mushroom supplementation (1%, 2%, and 3%). Results showed that the 1:8 ratio combined with 2% mushroom yielded tofu with balanced sensory attributes, moderately soft texture, slight crispness contributed by the mushroom, and the highest recovery yield (66.82%). In the second experiment, the optimal tofu formulation was stored for 10 days at 4 ± 2 °C using three types of packaging: polyethylene (PE), polypropylene (PP), and vacuum-sealed polyamide (PA). Sensory characteristics, texture firmness, and total aerobic microbial counts were monitored periodically. Vacuum-sealed PA packaging best maintained product quality, with a slight decrease in firmness (from 75.34 N to 65.37 N) and microbial counts remaining within safe limits. In contrast, samples stored in PE and PP packaging exhibited quality degradation starting from day 6 and exceeded microbiological safety thresholds by the end of the storage period. These results indicate that the combination of a 1:8 soybean-to-water ratio, 2% A. auricula-judae supplementation, and vacuum-sealed PA packaging is an optimal approach to improve the quality and extend the shelf life of tofu enriched with wood ear mushroom.*

Keywords: *Packaging, Preservation, Sensory quality, Texture, Tofu, Wood ear mushroom.*

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ẢNH HƯỞNG CỦA TỶ LỆ NGUYÊN LIỆU VÀ BAO BÌ BẢO QUẢN ĐẾN CHẤT LƯỢNG ĐẬU HŨ BỔ SUNG NẤM MÈO (*Auricularia auricula-judae*)

Đoàn Phương Linh*, Nguyễn Thị Hồng Xuyên, Nguyễn Xuân Hồng và Bùi Thị Ngọc Thảo

Khoa Công nghệ Sinh Hóa - Thực phẩm, Trường Đại học Kỹ thuật - Công nghệ Cần Thơ, Việt Nam

**Tác giả liên hệ, Email: dplinh@ctuet.edu.vn*

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Tóm tắt

Nghiên cứu này nhằm đánh giá ảnh hưởng của tỷ lệ đậu nành:nước trong quá trình xay, hàm lượng bổ sung nấm mèo (Auricularia auricula-judae) và loại bao bì bảo quản đến chất lượng cảm quan, cấu trúc và khả năng bảo quản của sản phẩm đậu hũ. Thí nghiệm thứ nhất được thực hiện với ba mức tỷ lệ đậu:nước (1:7, 1:8, 1:9) và ba mức bổ sung nấm mèo (1%, 2%, 3%). Kết quả cho thấy công thức 1:8 kết hợp 2% nấm mèo cho sản phẩm có cảm quan hài hòa, cấu trúc mềm vừa phải, độ giòn nhẹ của nấm mèo và hiệu suất thu hồi cao nhất (66,82%). Ở thí nghiệm thứ hai, sản phẩm từ công thức tối ưu được bảo quản trong 10 ngày ở 4 ± 2 °C bằng ba loại bao bì: PE, PP và PA hút chân không. Các chỉ tiêu cảm quan, độ cứng và tổng số vi sinh vật hiếu khí được theo dõi định kỳ. Bao bì PA hút chân không duy trì chất lượng tốt nhất với độ cứng giảm nhẹ (từ 75,34 N xuống 65,37 N) và vi sinh vật trong giới hạn cho phép. Mẫu PE và PP suy giảm chất lượng từ ngày thứ 6 và vượt ngưỡng vi sinh vào cuối chu kỳ bảo quản. Kết quả cho thấy công thức sử dụng tỷ lệ đậu:nước 1:8, bổ sung 2% nấm mèo và bảo quản trong bao bì PA hút chân không là giải pháp tối ưu để nâng cao chất lượng và kéo dài thời hạn sử dụng của đậu hũ bổ sung nấm mèo.

Từ khóa: *Bao bì, Bảo quản, Chất lượng cảm quan, Cấu trúc, Đậu hũ, Nấm mèo.*

1. Introduction

Tofu is a traditional food product that originated in China and is widely consumed in various Asian countries, including Vietnam, Japan, and South Korea (Wang et al., 2020). It is produced from soymilk through protein coagulation, forming a nutrient-rich gel matrix containing essential amino acids, isoflavones, and antioxidants (Yin et al., 2020). Several studies have demonstrated that regular tofu consumption can reduce the risk of hypertension, dyslipidemia, and cardiovascular diseases (Kim & Wicker, 2005).

However, conventional tofu presents limitations such as a soft texture, high perishability, and short shelf life. Therefore, improvements in formulation and processing are essential to enhance product quality and extend shelf stability. Among the potential approaches, the incorporation of wood ear mushroom (*Auricularia auricula-judae*), a fiber-rich ingredient containing minerals and bioactive compounds, has been suggested as a promising strategy to increase crispness, improve sensory attributes, and enhance nutritional value (Kadnikova et al., 2015).

In addition to ingredients, technological parameters such as the soybean-to-water ratio during grinding and the type of packaging also significantly influence gel structure, sensory characteristics, and product shelf life (Xu et al., 2020). Packaging materials such as polyethylene (PE) bags and vacuum-sealed pouches exert different effects on tofu preservation. Despite cold storage, tofu remains highly perishable due to its high moisture and protein content, which provide favorable conditions for microbial growth (Zheng et al., 2020).

Despite the commercial availability of tofu products containing wood ear mushroom, in-depth scientific studies specifically investigating its incorporation remain scarce. Most existing research has focused on other ingredients, such as purple sweet potato, with limited data on the impact of *A. auricula-judae* on tofu's sensory and textural properties. Therefore, this study was conducted to evaluate the effects of the soybean-to-water ratio, wood ear mushroom supplementation level, and packaging method on the sensory quality, structural integrity, and recovery yield of tofu. The objective is to propose an optimized formulation that meets modern consumer expectations while enhancing product stability.

2. Materials and methods

2.1. Materials and chemicals

The soybeans used in this study were uniform in size, free from damaged, deformed, or moldy seeds, and exhibited a consistent bright yellow seed coat. The wood ear mushrooms (*Auricularia auricula-judae*) were used in dried, pre-sliced form, with a uniform dark brown color, intact morphology, and no signs of breakage or spoilage.

All food-grade additives and analytical-grade chemicals were purchased from Cemaco Vietnam Co., Ltd., Can Tho branch. Plate Count Agar (PCA) medium, imported from India, was used for quantitative analysis of total aerobic bacteria, in accordance with microbiological standards.

2.2. Preparation of tofu enriched with wood ear mushroom

Soybeans were soaked in continuously flowing water for 6 hours. After soaking, the hulls were removed, and the beans were rinsed and ground for 2.5 minutes using water according to the designated soybean-to-water ratios. The resulting slurry was filtered through cloth to obtain soymilk, separating the okara. The soymilk was heated to 90 °C and maintained at this temperature for 15 minutes (Tran et al., 2025). Rehydrated and finely chopped wood ear mushrooms were added during the heating stage at the specified supplementation levels.

Coagulation was induced by adding 0.2% $MgCl_2$ to the soymilk, with gentle stirring until curd formation, followed by a 15-minute rest period to allow curd stabilization (Tran et al., 2025). The curd was transferred into a mold (10 × 6.5 × 7.5 cm) lined with filter cloth. Pressing was carried out by placing a 1.5 kg weight on top of the curd for 2 hours to achieve a firm tofu structure (Nguyen et al., 2021). The final tofu products were stored at 4 ± 2 °C in different packaging materials to assess the effect of packaging on product preservation quality.

2.3. Experimental design

2.3.1. Effect of soybean-to-water ratio and wood ear mushroom supplementation on product quality

The selected supplementation levels of wood ear mushroom (1%, 3%, and 5%) were based on preliminary trials, representing low, medium, and high concentrations to observe their effects on the sensory balance and texture of the product.

This experiment aimed to determine the optimal soybean-to-water ratio and wood ear mushroom (*Auricularia auricula-judae*) supplementation level to produce tofu with superior sensory attributes. A completely randomized design was employed with two factors: soybean-to-water ratio (1:7, 1:8, and 1:9) and mushroom supplementation level (1%, 3%, and 5%).

Tofu was prepared under the procedure described in Section 2.2. After soaking, soybeans were dehulled, rinsed, and ground for 2.5 minutes with water volumes corresponding to each tested ratio. The slurry was filtered through cloth to separate the soymilk from the residue. The obtained soymilk was heated to 90 °C and maintained for 15 minutes. Pre-soaked and finely chopped wood ear mushrooms were then added at the respective supplementation levels.

Coagulation was induced by adding 0.2% $MgCl_2$ to the soymilk, followed by gentle stirring until curd formation. The mixture was left undisturbed for 15 minutes to allow complete curd setting. The resulting curd was transferred into a mold (10 × 6.5 × 7.5 cm) lined with filter cloth and pressed with a 1.5 kg weight for 2 hours to obtain firm-textured tofu. The final products were stored at 4 ± 2 °C and subjected to sensory evaluation, texture measurement, and recovery yield analysis.

2.3.2. Effect of packaging type on the quality of tofu enriched with wood ear mushroom

This experiment aimed to determine the most suitable packaging material for extending the shelf life and maintaining the quality attributes of mushroom-enriched tofu. A completely randomized design (CRD) was used with one factor - packaging type - consisting of three levels: polyethylene (PE), polypropylene (PP), and vacuum-sealed polyamide (PA).

Tofu samples were prepared following the procedure described in Section 2.2, then packaged using the selected materials and stored under refrigerated conditions at 4 ± 2 °C for 10 days. During storage, quality indicators including total aerobic microbial count and texture firmness were analyzed every two days. Sensory evaluation was conducted on day 0 and day 10 to assess changes in sensory quality over time and to evaluate the effectiveness of each packaging material in preserving product stability and overall quality.

2.4. Analytical methods

In this study, product quality parameters were analyzed using standardized methods to ensure high accuracy and repeatability. Total protein content was determined using the Kjeldahl method (TCVN 8125:2015), while total lipid content was measured using Soxhlet extraction (TCVN 10730:2015). Product firmness was assessed using a CT3 Texture Analyzer

(Brookfield Ametek, USA). Each tofu sample was measured at four corner points and the center, with three replicates per position. The instrument was operated in Texture Profile Analysis (TPA) mode using a TA 48 probe, with the following settings: target compression distance of 8 mm, trigger load of 3 g, and test speed of 4 mm/s (Huang et al., 2022a).

Recovery yield was calculated as the ratio between the initial weight of raw soybeans and the final weight of fresh tofu, following the method of Zhang et al. (2016). Sensory evaluation was performed using a scoring method based on the Vietnamese national standard TCVN 3215-79. The sensory evaluation panel consisted of 15 trained members (8 females, 7 males) aged between 20 and 25, who were familiar with tofu sensory properties. Total aerobic mesophilic bacteria, yeasts, and molds were enumerated by the pour plate method, following the procedure described by Wise (2006).

All chemical analyses in this study were conducted by the research team at the Laboratory of the Faculty of Biological, Chemical and Food Technology, Can Tho University of Technology. Each test was performed in triplicate to ensure the accuracy and reliability of the results.

2.5. Statistical Analysis

All experimental data were processed and analyzed using Statgraphics Centurion XVIII software. Each experiment was conducted in triplicate to ensure accuracy. Analysis of variance (ANOVA) followed by the Least Significant Difference (LSD) test was applied to determine statistically significant differences among means at a confidence level of $p < 0.05$. Experimental results were visualized using charts and processed with Microsoft Excel 2010 (Microsoft Corporation, USA). Statistical analyses were conducted to ensure the precision and reliability of the obtained results.

3. Results and discussion

3.1. Effect of soybean-to-water ratio and wood ear mushroom supplementation on product quality

The amount of water added during soybean grinding is a critical factor that directly influences the physicochemical and sensory properties of tofu. Water not only facilitates the extraction of proteins from soybeans but also plays a vital role in gel formation during coagulation. An appropriate water ratio enhances protein extraction, strengthens the protein gel network, and improves product yield (Nguyen et al., 2018).

Additionally, wood ear mushroom (*Auricularia auricula-judae*) is a fiber-rich and nutritionally valuable additive. When incorporated at suitable levels, it can improve the texture, crispness, and sensory appeal of tofu. However, the supplementation level must be carefully controlled, as it directly affects the product’s color and protein gel structure.

Sensory evaluation results (Table 1) indicated that both the soybean-to-water ratio and mushroom supplementation level had significant effects ($p < 0.05$) on color, texture, and flavor, while aroma was not significantly affected ($p > 0.05$). Among the tested formulations, the sample prepared with a 1:8 soybean-to-water ratio and 2% mushroom addition achieved the highest scores across all four sensory attributes. This formulation provided an optimal balance of characteristic ivory-white color, mild crispness from the mushroom, and a moderately soft, smooth texture.

At a low supplementation level (1%), the mushroom did not significantly enhance structure or color. In contrast, excessive addition (3%) negatively affected sensory quality due to the overpowering dark brown hue of the mushroom, which masked tofu's natural whiteness and disrupted the homogeneity of the protein gel network.

Table 1. Sensory evaluation scores of tofu at different soybean-to-water ratios and wood ear mushroom levels

Soybean-to-water ratio	Mushroom level (%)	Color (*)	Texture (*)	Aroma (*)	Flavor)(*)
1:7	1	$2.83^{a} \pm 0.12$	$3.67^{c} \pm 0.15$	$3.83^{a} \pm 0.12$	$4.10d^{e} \pm 0.11$
	2	$3.80^{cd} \pm 0.14$	$4.17^{d} \pm 0.10$	$3.87^{a} \pm 0.09$	$3.90^{cd} \pm 0.10$
	3	$2.73^{a} \pm 0.11$	$3.40^{bc} \pm 0.12$	$3.90^{ab} \pm 0.13$	$3.73^{bcd} \pm 0.13$
1:8	1	$4.10^{d} \pm 0.10$	$4.40^{d} \pm 0.09$	$4.00^{ab} \pm 0.11$	$4.30^{e} \pm 0.10$
	2	$\mathbf{4.73^{e}} \pm 0.13$	$\mathbf{4.93^{e}} \pm 0.12$	$\mathbf{4.17^{b}} \pm 0.14$	$\mathbf{4.70^{f}} \pm 0.13$
	3	$3.80^{cd} \pm 0.15$	$3.57^{c} \pm 0.12$	$3.83^{a} \pm 0.10$	$3.97^{de} \pm 0.11$
1:9	1	$3.43^{b} \pm 0.14$	$3.17^{b} \pm 0.13$	$3.87^{a} \pm 0.12$	$3.27^{a} \pm 0.12$
	2	$3.50^{c} \pm 0.12$	$2.80^{a} \pm 0.11$	$3.77^{a} \pm 0.13$	$3.43^{ab} \pm 0.13$
	3	$3.20^{b} \pm 0.11$	$2.83^{a} \pm 0.10$	$3.83^{a} \pm 0.11$	$3.57^{ab\ c} \pm 0.08$
		P = 0.00	P = 0.00	P = 0.31	P = 0.00

Note: (*) Values represent the mean of three replicates. Different superscript letters within the same column indicate statistically significant differences at the 5% level.

Hardness measurements (Table 2) confirmed the significant impact of the soybean-to-water ratio on tofu texture. Samples prepared with a low water ratio (1:7) exhibited the highest hardness values (87.78 - 97.11 N), whereas those with a high water ratio (1:9) had the lowest (52.11 - 64.56 N). The intermediate ratio (1:8) resulted in tofu with moderate hardness (70.67 - 80.89 N), providing a balance between structural integrity and consumer-acceptable texture.

These variations are mainly due to differences in protein concentration. Lower water levels lead to higher protein and solid content in soymilk, enhancing protein - protein interactions and forming denser gels. However, excessive hardness may compromise palatability. In contrast, higher water levels dilute protein content, weaken network formation, and produce softer, less cohesive gels (Zheng et al., 2020).

The tofu sample prepared with a 1:8 soybean-to-water ratio and 2% mushroom addition exhibited the best balance of sensory attributes, as illustrated in Figure 1.

Figure 1. Tofu product enriched with wood ear mushroom (*Auricularia auricula-judae*)

Compared to commercial tofu products, the experimental tofu formulated with a 1:8 soybean-to-water ratio and 2% wood ear mushroom supplementation exhibited comparable hardness, aligning well with consumer texture preferences.

Table 2. Tofu hardness at different soybean-to-water ratios and wood ear mushroom supplementation levels

Soybean-to-Water Ratio	Wood Ear Mushroom (%)	Hardness (N) (*)
	1	97.11^{i} ± 2.34
1:7	2	91.33^{h} ± 1.85
	3	87.78^{g} ± 2.10
	1	80.89^{f} ± 1.92
1:8	**2**	**74.00**^{e} ± 1.67
	3	70.67^{d} ± 2.11
	1	64.56^{c} ± 1.73
1:9	2	59.22^{b} ± 1.44
	3	52.11^{a} ± 1.62
		P = 0.02

Note: (*) Values represent the mean of three replicates. Different superscript letters within the same column indicate statistically significant differences at the 5% level.

As shown in Table 3, the tofu recovery yield increased when the water ratio was raised from 1:7 to 1:8 but decreased when further increased to 1:9. The 1:8 ratio produced the highest yield (66.82%). This is attributed to the optimal water volume that enhances protein solubilization and promotes effective protein–protein interactions for uniform gel formation. At a 1:7 ratio, the limited water results in high concentrations of proteins and solutes, which impairs coagulant performance due to difficulty achieving the optimal pH range (4 - 5.5) for gelation. At 1:9, the soymilk becomes overly diluted, reducing protein density and limiting gel network formation, thus decreasing yield (Nguyen et al., 2018).

Table 3. Recovery yield of tofu at different soybean-to-water ratios

Soybean-to-Water Ratio	Recovery yield (%) (*)
1:7	66.30^{b} ± 0.41
1:8	**66.82**^{b} ± 0.38
1:9	63.03^{a} ± 0.51
	P = 0.00

Note: (*) Values represent the mean of three replicates. Different superscript letters within the same column indicate statistically significant differences at the 5% level.

The data above show that the combination of a 1:8 soybean-to-water ratio with 2% *A. auricula-judae* addition is optimal for producing high-quality tofu in terms of sensory attributes and recovery yield. This finding aligns with previous studies (Nguyen et al., 2018).

Table 4. Chemical composition of tofu enriched with wood ear mushroom

Parameter	Content (%) (*)
Moisture	73.79 ± 0.45
Protein	12.18 ± 0.31
Lipid	8.91 ± 0.27
Total sugars	0.60 ± 0.05

Note: (*) Values represent the mean of three replicates.

The results in Table 4 show that the mushroom-enriched tofu contains 73.79% moisture - consistent with firm tofu classification - while maintaining a smooth, soft texture. The protein content was 12.18%, lipid 8.91%, and total sugars 0.60%, reflecting a balanced nutritional profile in line with health-oriented food trends. These values are comparable to findings by

Nguyen et al. (2018), confirming the effectiveness of incorporating plant-based ingredients to enhance both nutritional quality and sensory characteristics of tofu.

3.2 Effects of packaging type on the quality of tofu enriched with wood ear mushroom

The structural degradation of tofu during storage is summarized in Table 5. A clear decline in hardness was observed over time. After 10 days of storage, samples packaged in polyethylene (PE) showed the most significant loss in texture, with hardness decreasing to 39.06 N, resulting in a mushy product with unacceptable sensory quality. Tofu stored in polypropylene (PP) retained better structure (46.97 N), while vacuum-sealed polyamide (PA) maintained the best structural integrity, with a hardness value of 65.37 N.

This deterioration is primarily attributed to changes in the protein gel network, which governs the hardness and elasticity of tofu. As a protein-rich gel system, tofu relies on protein - protein and protein - water interactions for its structure. During extended storage - especially in packaging with high oxygen permeability such as PE and PP, or in the presence of residual oxygen - oxidative reactions and water redistribution occur. Bound water is released as free moisture, increasing total water content while weakening protein bonds. The breakdown of soluble proteins and microbial or oxidative protein denaturation further disrupts the gel matrix, significantly reducing both hardness and elasticity (Huang et al., 2022b).

The extent of structural degradation is closely linked to the oxygen permeability of the packaging material. Vacuum-sealed PA has a very low oxygen transmission rate (50 - 75 ml/25 µm/m²·day·atm), far lower than that of PP (3500 - 4500) and PE (6500 - 8500) (Peter et al., 2018), which explains its superior ability to preserve tofu structure over time.

Table 5. Changes in tofu hardness during storage under different packaging conditions

Storage time (days)	Packaging type	Hardness (N) (*)
0	PE	$75.34^{a} \pm 0.28$
	PP	$75.34^{a} \pm 0.28$
	Vacuum-sealed PA	$75.34^{a} \pm 0.28$
2	PE	$73.11^{f} \pm 0.31$
	PP	$73.42^{d} \pm 0.26$
	Vacuum-sealed PA	$75.00^{b} \pm 0.24$
4	PE	$70.03^{k} \pm 0.33$
	PP	$72.12^{g} \pm 0.27$
	Vacuum-sealed PA	$74.19^{c} \pm 0.22$
6	PE	$68.04^{l} \pm 0.36$
	PP	$71.31^{h} \pm 0.29$
	Vacuum-sealed PA	$73.28^{e} \pm 0.25$
8	PE	$62.45^{o} \pm 0.42$
	PP	$64.32^{n} \pm 0.38$
	Vacuum-sealed PA	$70.14^{i} \pm 0.30$
10	PE	$39.06^{q} \pm 0.47$
	PP	$46.97^{p} \pm 0.44$
	Vacuum-sealed PA	$65.37^{m} \pm 0.36$
		P = 0.00

Note: (*) Values represent the mean of three replicates. Different superscript letters within the same column indicate statistically significant differences at the 5% level.

Total viable count (TVC) is an important microbiological indicator of spoilage and depends on both product composition and storage conditions (Huang, 2022). During 10-day storage, TVC increased in all samples. Notably, PE-packaged samples exceeded the safety threshold ($>10^6$ CFU/g) by day 8. PP-packaged samples reached this threshold by day 10. In contrast, vacuum-sealed PA packaging maintained TVC below the acceptable limit ($\leq 10^6$ CFU/g), as regulated by the Vietnam Ministry of Health (2007), throughout the storage period. This confirms the superior microbial control of vacuum-sealed PA compared to PE and PP.

Table 6. Total viable count (CFU/g) of tofu during storage under different packaging conditions

Storage time (days)	PE	PP	Vacuum-sealed PA
0	<1	<1	<1
2	$(1.3 \pm 0.09)\times10^3$	$(1.1 \pm 0.09)\times10^3$	$(5.2 \pm 0.08)\times10^2$
4	$(3.2 \pm 0.2)\times10^3$	$(2.4 \pm 0.2)\times10^3$	$(1.1 \pm 0.1)\times10^3$
6	$(1.2 \pm 0.1)\times10^4$	$(1.1 \pm 0.1)\times10^4$	$(6.3 \pm 0.3)\times10^3$
8	$>10^6$	$(1.2 \pm 0.2)\times10^5$	$(3.8 \pm 0.4)\times10^4$
10	$>10^6$	$>10^6$	$(1.0 \pm 0.1)\times10^5$

Note: (*) Values represent the mean of three replicates.

Tofu enriched with wood ear mushroom has high nutritional value, especially in terms of protein and moisture. However, these properties also provide a favorable environment for microbial growth. Without proper preservation, the product spoils rapidly.

Among available packaging technologies, vacuum-sealed PA stands out for its ability to remove most oxygen and provide excellent gas barrier properties. This low-oxygen environment limits aerobic microbial activity, extending product shelf life. According to Lee et al. (2009), vacuum packaging can prolong tofu shelf life up to 12 days at 5 °C, whereas other packaging types fall short. In addition to microbial control, vacuum packaging helps stabilize other quality parameters such as pH and preserves sensory characteristics throughout storage. Conversely, PE and PP offer lower barrier protection, increasing the risks of oxidation and microbial spoilage. Although PP is less permeable than PE, its preservation performance remains inferior to PA.

Table 7. Packaging efficiency for tofu enriched with wood ear mushroom

Packaging type	Optimal quality duration (days)	Onset of sensory degradation (days)	Complete spoilage (days)	Remarks
PE	2	4 - 6	8	Rapid decline in texture, odor, and color after day 4; product became mushy with off-odors by day 8. High oxygen permeability makes it unsuitable for extended storage.
PP	4	6 - 8	10	Noticeable sensory decline after day 6, but acceptable quality

Packaging type	Optimal quality duration (days)	Onset of sensory degradation (days)	Complete spoilage (days)	Remarks
				retained until day 10. Performs better than PE but still limited due to relatively high gas permeability.
Vacuum-sealed PA	≥10	>10	>10	Maintained texture, flavor, and color throughout 10 days. Microbiological and sensory stability remained intact. High preservation efficiency attributed to low-oxygen environment and excellent gas barrier properties of vacuum-sealed PA material.

Additional testing under ambient temperature (28 ± 2 °C) further confirmed the impact of packaging on shelf life. PE- and PP-packaged samples retained acceptable quality for only 24 hours, whereas the vacuum-sealed PA sample maintained sensory and structural integrity for up to 36 hours.

In summary, vacuum-sealed PA packaging combined with cold storage (4 ± 2 °C) is the most effective method for extending the shelf life of tofu enriched with wood ear mushroom. This approach not only slows microbial growth but also preserves product texture and stabilizes sensory attributes throughout the storage period.

4. Conclusion

This study demonstrated that soybean-to-water ratio, wood ear mushroom (*Auricularia auricula-judae*) supplementation, and packaging type significantly influenced the sensory quality and texture of tofu. The optimal formulation was identified as a 1:8 soybean-to-water ratio with 2% mushroom, yielding balanced color, distinctive flavor, desirable texture, and the highest recovery yield (66.82%). Vacuum-sealed PA packaging under cold storage (4 ± 2 °C) effectively preserved product quality for up to 10 days by maintaining texture and limiting microbial growth, whereas PE and PP packaging were only effective for 6 - 8 days. Rapid quality degradation at room temperature highlights the importance of cold storage and suitable packaging.

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